26.0 CENTRAL CALIFORNIA COAST COHO SALMON ESU

26.1 BACKGROUND

26.1.1 Description of the ESU

The Central California Coast Coho Salmon (CCC) ESU extends from Punta Gorda in northern California to the San Lorenzo River in Santa Cruz, California, inclusive of the San Francisco Bay basin. It includes all naturally spawned populations of coho salmon in accessible river and tributary reaches within the ESU and any coho salmon found spawning south of the San Lorenzo River that have not resulted from stock transfers from outside the ESU. Also included in the ESU are the artificially propagated coho salmon stocks (and their progeny) at the Don Clausen Fish Hatchery, the Monterey Bay Salmon and Trout Project Kingfisher Flat Hatchery, and its associated captive broodstock at the Southwest Region Fisheries Science Center. The Noyo River coho salmon stock, previously propagated at the Noyo River Fish Station, is also part of the ESU. There are currently no other coho salmon stocks propagated within the CCC ESU.

26.1.2 Status of the ESU

The CCC ESU was listed as a threatened species on October 31, 1996 (61 FR 56138), due to the depressed numbers of naturally-produced coho salmon, the high risk of extinction for some populations, the number of environmental and human-caused threats to the species including hatchery impacts, and the lack of adequate regulatory protection to conserve the ESU. Statewide estimates for California populations of coho salmon numbered between 200,000 and 500,000 in the 1940s (61 FR 56138). CCC abundance was estimated at 56,100 in 1963, reduced to 18,050 by 1985, and further reduced to 6,160 in the late 1980s, with many populations comprising less than 100 individuals (CDFG 1965; Wahle & Pearson 1987; Brown *et al.* 1994; BRT 2003b). Habitat fragmentation and population declines in the ESU have resulted in small, isolated populations that face genetic risks from inbreeding, loss of rare alleles, and genetic drift. Based on the presence/absence data from 133 streams (72 percent of historical CCC coho salmon streams), 71 streams no longer had coho salmon runs. Coho salmon stocks south of San Francisco have a greater risk of extinction than the northern coho salmon populations (Brown *et al.*1994). More recent information confirms a high risk of extinction for the CCC ESU, specifically for populations of the Garcia, Gualala, Russian Rivers and tributaries of the San Francisco Bay (BRT 2003b).

26.2 ASSESSMENT OF HATCHERY PROGRAMS

The ESU includes a number of extant populations. In addition, the artificially propagated coho salmon stocks at Don Clausen Fish Hatchery, the Monterey Bay Salmon and Trout Project (MBSTP) Kingfisher Flat Hatchery, the corresponding Scott Creek captive broodstock held at the Southwest Fisheries Science Center, and the Noyo River Fish Facility are considered part of the listed CCC ESU. There are currently no other anadromous hatchery coho salmon being propagated within the CCC ESU. The following section presents a summary of the

broodstock/program history, similarity between hatchery-origin and natural-origin fish, program design, and program performance of these artificial propagation programs (Table 1).

Table 26.1. Artificial Propagation Programs which release coho salmon within the geographical area of the CCC ESU.

Program	Type	Included in ESU	Description	Production Level	Year Initiated
Don Clausen Hatchery	integrated	yes	yearling smolt	200,000	2001
Monterey Bay Salmon &Trout Project (Kingfisher Flat Hatchery)	integrated	yes	yearling smolt	75,000	2002
Noyo Egg Collecting Station	integrated	yes	yearling smolt	500,000	1961
Scott Creek Captive Broodstock (Southwest Fisheries Science Center)	integrated	yes	captive rearing	100 - 150	2002

26.2.1 Russian River Populations

The Russian River coho salmon populations have been severely reduced in presence and number and are now found primarily in the lower basin. The California Department of Fish and Game (CDFG 2002) estimated that before the construction of Warm Springs Dam, the Dry Creek subbasin supported approximately 300 coho salmon. There are no recent population estimates for coho salmon populations in the Russian River basin; presence/absence surveys found few streams containing coho salmon (CDFG2002). Green Valley Creek has the only persistent coho salmon population in the basin. Genetic analysis carried out by Hedgecock *et al*. (2003) indicated a high degree of inbreeding in Russian River populations. The Garza and Gilvert-Horvath report (2003) supported this result and inferred a genetic bottleneck in the Green Valley population. The previous coho salmon program (1980-1998) carried out at the Don Clausen Fish Hatchery (DCFH) released an annual average of 77,000 coho salmon yearlings, composed primarily of basin stocks. This program could not successfully sustain itself and required supplementation, even with an 85-percent broodstock composition of Russian River escapement from 1990 to 1995. The current DCFH program, which began in 2001, exclusively uses local native stock for its captive rearing program and is considered part of the CCC ESU.

26.2.1.1 Don Clausen Fish Hatchery Coho Salmon Program

26.2.1.1.1 Program History. The Russian River coho salmon conservation program began in 2001 in a concerted effort to halt the steep downward trend toward local and ESU extinctions. The program, funded by the Army Corps of Engineers with staff-funding support from the Sonoma Water County Agency, is managed by the CDFG. The program receives genetic and technical assistance from the Southwest Fisheries Science Center (SWFSC) and further support from a multi-agency/stakeholder Technical Oversight Committee on research and restoration

activities. A Hatchery and Genetic Management Plan guides the adaptive management of the DCFH coho salmon program. The captive rearing program will provide seed stock for current nonbearing coho salmon streams with appropriate habitat, preventing genetic impacts on the few coho populations in the Russian River system. Risk management will include planting two juvenile age classes (fingerling and advanced fingerling) to allow for variable rates of natural survival while encouraging fitness to the natural environment. The initial fish releases are planned for the fall of 2004.

26.2.1.1.2 Broodstock History. The DCFH program fish are collected from selected streams within the Russian River, or failing that, the Lagunitas-Olema system (SSHAG 2003). Since the initiation of the program, coho salmon have been collected from the Green Valley, Olema, Redwood, and Dutch Bill creeks. All potential broodstock are first genetically screened for the design of a spawning matrix that will maximize the number of family groups and promote diversity within the genome (FishPro and ENTRIX, Inc. 2004). Gametes will also be cryopreserved as needed, to ensure future representation of the full range of life history traits.

26.2.1.1.3 Similarity between Hatchery-origin and Natural-origin Fish. The source of program fish is local, native populations within the Russian River system. Fish releases will be the F1 (first-generation) progeny of captive, wild broodstock, 100-percent marked for visual monitoring and evaluation of the program. Program goals of genetic conservation and maximizing diversity will benefit the ESU, and a second planned captive broodstock will provide additional insurance against further loss of the Russian River genome. Hatchery fish will be planted within streams during an early rearing stage to encourage wild behavior traits and fitness to the natural habitat. Hatchery rearing protocols are being researched to ensure parallel development of program fish growth and size with that of wild coho salmon juveniles.

26.2.1.1.4 Program Design. The goals for the DCFH coho salmon program include the conservation of genetic resources of Russian River fish populations, using captive propagation methods. A secondary goal is to provide opportunity for research on the effective use of artificial propagation. Between 200 and 300 young of the year coho salmon fry may be collected and reared in captivity at the DCFH for use as program broodstock. The program proposes to eventually release 50,000 fingerlings and 50,000 advanced fingerlings into five Russian River tributaries (BRT 2003b). Their progeny will be stocked at the fingerling or advanced fingerling stage into coho salmon-extirpated streams with appropriate coho salmon habitat. The program will reinforce survival traits in F1 progeny fish by releasing them at an early rearing stage at the onset of favorable environmental conditions.

26.2.1.1.5 Program Performance. All advanced fingerlings will be 100-percent adipose clipped and coded-wire tagged in order to monitor outmigration at trapping locations. Visual implant elastomer tags will be deployed when multiple tributaries are stocked. Program performance will be evaluated for successful hatchery fish outmigration; monitoring of adult returns and subsequent redd surveys will provide data on program contribution to population productivity and spatial structure.

Continued operation of the DCFH coho salmon conservation program is certain, justified by the

risk of extinction due to threats from demographic variation, local environmental variation, and less than negligible genetic diversity changes over a 100-year time frame (NOAA Fisheries 2001). The DCFH program is crucial to the recovery of the natural coho salmon populations in the Russian River basin and will be expanded to include a captive broodstock component as further insurance for the program.

26.2.1.1.6 VSP Effects

Abundance - The coho salmon population within the Russian River basin is not expected to independently recover from variation in environmental or habitat conditions. Wild fish captured for captive rearing are removed from the population and impacts on the abundance of subsequent wild adult escapement are unknown.

Productivity - Conversely, the captive rearing environment impacts the fecundity of program fish. However, improvements in the captive rearing protocols and environment and the increase in the number of natural spawners via hatchery supplementation should provide a net benefit to the Russian River population.

Spatial structure - Keystone streams have been identified within the Russian River basin as suitable for planting coho salmon and from which the hatchery supplementation program can expand as populations become established.

Diversity - Tissue analysis of captured individual fish provides a genetic stock profile and guides choice of program fish based on genetic appropriateness to the Russian River system. Spawning matrices are designed to maximize genetic diversity and prevent further inbreeding in the highly depressed natural populations.

26.2.2 Scott Creek Population

Scott Creek watershed has undergone a severe decline of its wild coho salmon populations. The Scott Creek coho salmon population had been previously supplemented with an estimated 400,000 coho salmon, primarily from out-of-basin fish stocks, since 1909 (MacFarlane and Alonzo 2000). It is thought that heavy supplementation with hatchery stocks, compounded by density-dependent effects (e.g., genetic hybridization, competition, and predation of hatchery fish on the Scott Creek population) have accelerated its decline. Only Scott Creek fish are utilized in the MBSTP coho salmon conservation program, which is considered part of the CCC ESU.

26.2.2.1 Monterey Bay Salmon and Trout Project Coho Salmon Program

26.2.2.1.1 Program History. The MBSTP coho salmon program was originally established in 1982, and its artificial propagation efforts have allowed for coho salmon persistence in Scott Creek as other southern CCC stocks were extirpated. In 2002, the MBSTP coho salmon program was re-established as a conservation program for purposes of assisting the recovery of the threatened CCC coho salmon by supplementing naturally produced coho salmon in Scott Creek,

Waddell Creek, and Gazos Creek with hatchery-produced coho salmon (NOAA Fisheries 2002).

26.2.2.1.2 Broodstock History. There have been no out-of-basin fish transfers into the MBSTP program, and only Scott Creek coho salmon stock have been used as program fish (BRT 2003a). However, Scott Creek has been planted with exotic stocks since 1906, which may have influenced the current genetic profile of the local population. Genetic analysis groups together Scott Creek and Kingfisher Flat Hatchery samples as a branch of the Central California group (SSHAG 2003).

26.2.2.1.3 Similarity of Hatchery-origin to Natural-origin Fish. Program fish are collected from unmarked adult coho salmon returns to Scott Creek whenever possible to prevent the incorporation of hatchery fish into the program broodstock. However, spawning strategy has been determined by the availability and composition of adult returns to Scott Creek. Fish matings are prioritized in this preferred order: 1) wild x wild; 2) wild x hatchery; and 3) hatchery x hatchery. In 2003, a captive broodstock was established to support the MBSTP coho salmon conservation program and provide broodstock when natural adult returns are unavailable for collection from Scott Creek.

Program fish are utilized in recovery efforts, and their captive rearing may reflect program goals. Initial results of hatchery conservation program effects on wild juveniles showed that fish grew faster in captivity than in the wild, and fish growth could be intentionally accelerated to produce an early return by one year to fill in vacant-year classes (Hayes *et al.* 2004).

26.2.2.1.4 Program Design. The goal is to spawn up to 30 unmarked females and 45 unmarked males to obtain approximately 60,000 eggs for the program. Adult coho salmon are net-collected by divers in Big Creek, usually below the hatchery, but they may be collected throughout the Scott Creek system. The first 10 spawning pairs of coho salmon to be observed must be undisturbed (BRT 2003a). To ensure natural spawning, only one out of four females may be taken. A Scott Creek captive broodstock held at the SWFSC in Santa Cruz may supplement the artificial propagation program with adult spawners while minimizing the possibility of loss of the Scott Creek coho salmon genome in case the natural population suffer a catastrophe loss. Progeny from program broodstock are reared and released at locations authorized by NOAA Fisheries. A multi-agency Technical Oversight Committee has been established to consider all ongoing and future research and restoration activities and ensure that risks to the wild populations are minimized. Genotyping results determine which individuals to retain for broodstock in recovery and restoration efforts, minimize inbreeding, and maximize the effective population size. Program research is directed towards the interactions and potential impacts of hatchery-produced coho salmon on naturally produced salmonids within the areas targeted for restoration.

26.2.2.1.5 Program Performance. Scott Creek is surveyed for adult coho salmon distribution, and outmigrating juveniles are monitored on upper and lower Scott Creek and on Little, Big and Mill Creeks near their confluences. All four creeks are also inventoried for their abundance and distribution of suitable spawning and juvenile rearing habitat. Tissue analysis conducted on Scott Creek coho salmon provides information on emigration timing and osmoregulatory ability, as

well as gene flow within and among watershed populations. Future studies are proposed to determine straying rates for other basin stocks raised at the Kingfisher Flat Hatchery and released back into their native watersheds (Hayes *et al.* 2004).

26.2.2.1.6 VSP Effects. In consideration of the endangered status of the populations within the CCC, the risk to Scott Creek coho salmon population abundance, productivity, spatial structure, and diversity is minimal as a result of the continuation of the MBSTP coho salmon conservation program. Program fish are being planted in Scott and Waddell Creeks in years where cohorts have been extirpated. Scott and Waddell Creek coho salmon stocks are among the most closely related in California (Hayes *et al.*2004). Other tributaries with habitat identified as suitable for coho salmon may be chosen, based on degree of genetic relationship to the Scott Creek population. To prevent impacts to the remaining wild stocks of coho salmon in the southern portion of the CCC ESU, program fish will not be stocked in streams with viable cohorts.

26.2.2.2 Scott Creek Captive Broodstock Program

26.2.2.2.1 Program History. The Scott Creek captive broodstock program was begun in 2003 to provide broodstock for the MBSTP coho salmon program in years when there are not enough wild adults returning to Scott Creek. The genotypes of 500 coho salmon juvenile offspring of the 2001 broodyear from the MBSTP conservation program at Kingfisher Flat Hatchery were examined to confirm broodyear representation. Of the 500, 150 were held as the founding generation of the Scott Creek Coho Salmon Captive Broodstock program. The captive broodstock will be maintained at the SWFSC holding site until their maturity, at which time they will be available for incorporation into the artificial propagation program, if needed (Hayes *et al.*2004).

26.2.2.2.2 Similarity between Hatchery-origin and Natural-origin Fish. Program fish are collected from Scott Creek and therefore carry the genetic profile identifying the natural population. By design, a captive broodstock will genetically mirror and conserve the genome of the natural (and hatchery) population. Captive broodstock are never released from the hatchery environment and are spawned according to a matrix design that maximizes genetic diversity and effective population size.

26.2.2.2.3 Program Design. The captive broodstock is maintained at the SWFSC holding site until maturity, at which time the fish may be incorporated into the artificial propagation program. Captive fish will also contribute to the knowledge base of CCC coho through their use in research studies targeting coho salmon recovery. Broodstock gametes may be cryogenetically preserved for future spawning opportunities. Fish genotyping will direct the creation of a spawning matrix that will minimize inbreeding and maximize the retention of genetic variation and effective population size. Captive fish may be propagated to provide juveniles for the program at the SWFSC; fish may also continue to be provided by MBSTP.

26.2.2.2.4 Program Performance. The captive broodstock has been initiated only recently (2003). It is expected that, if necessary to provide broodstock for the MBSTP conservation program, the captive fish will minimize the chance of inbreeding and provide the opportunity to maximize genetic representation and variation of the Scott Creek coho salmon population (Hayes

*et al.*2004).

26.2.2.2.5 VSP Effects. Removal of juvenile progeny from the MBSTP coho salmon conservation program may prevent the possibility of increasing future abundance of the natural adult spawning population; however, this is offset by conservation of the present genome of the Scott Creek population, with the chance of contributing gamete material to future generations and minimizing the risk of further loss of genetic variability.

26.2.3 Noyo River Population

There were 377 coho redds observed in a CDFG spawning survey conducted in the Noyo River in 2000–2001 to quantitatively estimate the coho salmon population. The population estimate from the redd survey ranged between 539 and 571 coho salmon, with an AUC (area under the curve) estimate of 592 coho salmon. A total of 630 adult coho salmon were observed in the Noyo River between December 2000 and April 2001; of these, 626 fish were observed during the spawning surveys and four were observed during downstream fyke trapping (Gallagher 2001). Numbers of coho salmon returns appeared to be greater downstream of the Noyo River Fish Facility than in the upper South Fork Noyo River.

26.2.3.1 Noyo Egg Collecting Station Program (Noyo ECS)

26.2.3.1.1 Program History. Coho salmon were collected and spawned at the Noyo River Fish Station for most years between 1961 and 2003, and juveniles were reared at the Mad River Hatchery, Don Clausen Fish Hatchery, or the Silverado Fish Transfer Station (BRT 2003b). The purpose of the program was to enhance the coho salmon population in the Noyo River. The program, which was discontinued in 2003, did not appear to be contributing to coho salmon population abundance. The increasing majority of adult escapement to the hatchery were marked fish; however, numbers of adult returns were decreasing overall (average 524 trapped fish 1991-2001; 16 and 25 trapped fish in 1998 and 1999, respectively) (SSHAG 2003). It is not known if hatchery fish were supplanting the natural population, or if there were factors influencing both hatchery and natural coho salmon returns.

26.2.3.1.2 Broodstock History. There are no records of broodstock from any other source but the Noyo River; however, there have been out-of-basin transfers into the Noyo River itself (SSHAG 2003). Local, natural fish were incorporated into the program broodstock in unknown proportions.

26.2.3.1.3 Similarity between Hatchery-origin and Natural-origin Fish. Noyo ECS adult coho salmon return during the natural run timing in the Noyo River. Coho salmon are observed in the Noyo River estuary in mid-October and may be present in the river from November through February, peaking in late December through early January (Gallagher 2001). In the 2000-2001 coho salmon spawning survey, three marked hatchery coho salmon carcasses were noted in the lower river, and one hatchery marked carcass was found in the upper river (Gallagher 2001). This indicates that some Noyo River ECS fish were part of the natural spawning population. Hedgecock *et al.* (2003) reported that microsatellite data analysis shows the Noyo River coho

salmon stock samples clustering tightly with other coho stocks south of the Eel River (SSHAG 2003).

26.2.3.1.4 Program Design. The program was designed to increase numbers of coho salmon in the Noyo River beyond natural production. Fish gametes were collected at the Noyo River Fish Station, and the fertilized eggs were cultured at Mad River Hatchery, Don Clausen Fish Hatchery, or the Silverado Fish Transfer Station. The fish were released as yearling smolts back into the Noyo River downstream of the fish station. Only Noyo River stock was used for the program, which incorporated both hatchery and natural coho salmon into the broodstock.

26.2.3.1.5 Program Performance. The Noyo River ECS was discontinued in 2003 due to the decline of adequate numbers of coho salmon returns to continue the program, an indication that the program was no longer viable. There was no corresponding monitoring to provide information for program evaluation.

26.2.3.1.6 VSP Effects. There has been no monitoring of the effects of the Noyo River ECS on the Noyo River coho salmon population. Consistent data have been limited to numbers of coho salmon returning to the Noyo River Fish Facility. The last two broodyears (1998 and 1999) saw a severe reduction in coho salmon numbers entering the facility, and the program became non-sustainable thereafter. There is some indication of possible hatchery contribution to the spawning river population (Gallagher 2003), and a 2000-2001 Noyo River survey observed greater numbers of coho salmon below the fish station than above the facility.

26.3 CONCLUSIONS

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